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Drought identification and characterisation of semi-arid districts of North Karnataka

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ABSTRACT: The present study was carried out to identify drought and its characteristics in the northern part of Karnataka. The results showed negative trends, in the entire area in the annual and seasonal rainfall departure from its normal for most of years indicating a deficit in rainfall. The area was observed to be experiencing a drought of moderate intensity with a recurrence interval of 4 to 5 years. The spatial distribution of various drought affected zones within the study area based on probabilistic approach have been carried out and mapped in a GIS environment. It revealed that the entire study area falls under moderate drought affected zone except a small part of Jamkhandi taluka in Bagalkot district and Gangavati taluka in Koppal district. With an average of two dry spells with a length of 22 days, the effective monsoon in the area commences from the last week of June. Hence, for formulating a drought mitigation strategy in this area, it is recommended that soil and water conservation measures be implemented and water harvesting measures be carried under watershed development programmes like contour bunding, nala plugging and constructing gabions structures etc., to conserve available water resources for subsequent life saving irrigation to crops during periods of dry spell.

Key words: Drought; Dry spell; Effective monsoon; Probability; Rainfall

Drought is a frequent phenomenon in India, affecting some part or the other of the country. More than 100 districts spread over 16 states of India have been identified as drought prone districts, out of these, about 15 districts occur in the Karnataka (Standing Committee on Agriculture 2003). Even though the main cause of drought is inadequate rainfall, information on drought characteristics like its duration and intensity is of important value to planners for formulating effective drought management strategies. Drought is generally viewed as a sustained phenomenon occurring mainly due to lower precipitation and soil moisture deficit as compared to their normal value. It affects all other resources *viz*; water supply, water quality, crop production and productivity, power generation, riparian habitats and recreation activities as well as a host of other associated economic and social activities (Connie and Jonathan 1998). The adverse effects of drought can be mitigated to a large extent by proper drought management strategies.

Even though various types of definitions or indices are being used by various researchers (Palmer 1957; Apparao 1983; Houghton 1994; Pandey 1999; Ponce *et al.* 2000), droughts are analyzed and characterized by the selected set of variable(s) on the basis of magnitude (average water deficiency), duration (period of water deficit), severity (cumulative water deficiency), frequency (probability of drought occurrence) and beginning and ending of drought.

In India, there are evidences of continuous terrible famines for nearly 12 years during 310-298 B. C. During a severe drought in 1917-18, the river Jhelum dried up completely in Kashmir. Though the annual rainfall of Karnataka is 1139 mm, received over 55 rainy days, the distribution with space and time is not uniform. The annual rainfall varies from as low as 562 mm in central eastern district of Bagalkot to 4119 mm in the coastal district of Udupi. Though the main cause of drought is inadequate rainfall, information on drought characteristics like its duration and intensity, onset of effective monsoon and occurrences of dry spell is of great value to planners for designing storage capacity of a small reservoir to take care of irrigation requirements during drought periods and also for planning of supplemental irrigation especially in semi-arid and arid regions. The present study was carried out in semi-arid districts of north Karnataka namely, Bijapur, Bagalkot, Raichur and Koppal to investigate the occurrence of drought and its characteristics for crop planning and strategies for drought mitigation. An effort has also been made in the present study using a GIS platform to map spatial distribution of various drought affected zones within the study area based on probabilistic approach.

MATERIAL AND METHODS

The study area falls under semi-arid region with more than 75% of the cultivable area as rainfed. Agricultural production is mainly dependant on rainfall. *Kharif* (June to September) and *rabi* (October to December) are major crop

Table1. *Percent departure of rainfall in various districts of the study area*

Year	Name of District							
	Koppal		Raichur		Bagalkot		Bijapur	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
1965	-3.08	37.79	9.72	11.60	-3.07	14.18	-8.97	20.99
1966	-17.27	-29.20	10.90	4.30	6.44	-16.46	-15.13	-1.07
1967	-10.04	-1.91	4.56	14.70	17.72	2.21	-5.87	-9.85
1968	4.01	9.91	13.66	5.38	16.49	7.08	13.47	12.21
1969	10.96	-7.04	1.34	-16.75	2.23	1.95	-17.38	-4.79
1970	13.29	22.11	8.86	13.36	22.60	22.93	-16.62	-7.41
1971	-23.44	-36.56	-17.08	-45.15	21.82	-10.66	3.40	-14.65
1972	-34.90	-23.23	-25.15	-35.92	-11.67	-31.07	-49.07	-56.45
1973	-3.59	-1.04	15.35	-15.76	-0.80	8.86	14.03	-3.99
1974	41.64	50.46	1.28	-10.97	31.47	35.66	11.94	3.24
1975	61.68	30.16	92.49	58.94	43.62	16.07	72.83	34.16
1976	-32.40	-22.15	-17.18	-21.32	-40.73	-22.54	-36.66	-18.10
1977	-10.55	-27.12	12.90	2.76	19.21	-7.78	4.95	-22.52
1978	8.92	2.84	31.97	43.78	23.24	13.52	31.26	22.93
1979	17.32	48.89	7.79	20.02	-2.69	13.93	28.15	41.12
1980	-21.87	-11.74	-19.76	-1.04	-26.50	-8.75	-12.85	14.69
1981	37.93	69.05	20.00	14.22	42.89	61.29	47.59	89.61
1982	-4.44	-2.27	7.73	6.58	-2.49	-5.87	-5.95	-6.72
1983	-5.53	21.69	10.02	55.35	-15.04	14.78	-9.21	15.96
1984	-20.23	-16.17	-18.40	-18.55	-19.93	-31.46	-9.58	4.80
1985	-41.27	-37.72	-16.02	-25.03	-43.83	-43.28	-30.36	-30.26
1986	-13.00	-14.67	-19.63	-23.11	-1.83	5.87	-30.28	-25.98
1987	10.87	7.63	16.05	20.80	25.25	18.99	26.27	4.33
1988	11.87	42.90	4.81	54.09	-7.04	14.23	17.43	43.06
1989	-18.71	0.74	-17.31	-8.61	-13.74	12.48	16.84	43.30
1990	-2.11	-11.71	-6.48	-16.06	-21.50	-37.77	-8.59	-30.33
1991	-5.98	6.15	-13.31	-9.22	22.02	36.11	1.14	15.28
1992	18.71	-22.85	-15.78	-34.54	-20.90	-28.67	-22.05	-22.03
1993	41.85	22.36	-12.23	-26.02	7.68	-29.09	7.90	-20.26
1994	-18.81	-57.58	-30.37	-69.37	-29.60	-48.82	-28.68	-65.92
1995	3.42	-0.93	-10.21	-11.15	12.58	-1.11	-0.57	-15.29
1996	59.03	84.99	10.98	-4.56	24.16	47.43	32.22	45.12
1997	-31.51	-39.09	-27.48	-10.03	4.61	-31.22	-23.52	-35.38
1998	14.71	31.83	20.77	42.54	64.85	-25.60	55.93	59.38
1999	8.12	-18.99	-6.84	-18.56	12.44	-13.00	7.04	-19.61
2000	20.62	16.98	6.92	9.77	8.48	12.23	7.60	0.39
2001	-1.22	-1.41	15.20	6.95	-7.10	-1.22	-1.15	0.16
2002	-24.59	-39.84	-18.90	-39.91	-25.31	-44.18	-17.36	-34.68
2003	-41.75	-53.10	-14.56	-4.59	-53.62	-63.33	-39.02	-29.51
2004	1.33	7.54	-5.41	-22.41	-5.10	10.01	-4.96	-2.15

seasons in the region. The south-west monsoon plays a major role in crop production. Long-term records of daily rainfall for 45 stations located in 20 talukas of 4 districts of north Karnataka namely Bagalkot, Bijapur, Raichur and Koppal were collected from the District Statistical Offices, and the data subjected to various kind of analysis including annual and seasonal rainfall departures, probability distribution and dry spell analysis etc. The method suggested by Indian Meteorological Department (IMD) were used for assessment of the drought years. A year was considered as drought year if the total amount of annual rainfall over an area is deficient by more than 25% of its normal value (Apparao 1983).

Drought has three essential characteristics viz; intensity, duration and spatial coverage. Intensity refers to the degree of precipitation shortfall and/or the severity of impact associated with the shortfall. It is generally measured by the departure of some climatic index from the normal and is closely linked to

duration in the determination of impact. The magnitude of drought impact is closely related to the timing of the onset of precipitation, its intensity and duration. The conceptual model for drought characterization was used for determination of intensity, duration and frequency of the drought (Ponce *et al.* 2000). The IMD norm was followed to categorise the entire area into various drought affected zones. Accordingly, an area can be considered as moderate drought affected zone if the probability of occurrence of 75% of normal rainfall is less than 80%. If the probability of occurrence of 75% of normal rainfall is less than 60%, the area can be considered as chronically severe drought affected zone (CWC 1982 ; Ramakrishna *et al.* 1984). Using the Integrated Land and Water Information System (ILWIS), GIS software, a spatially distributed map showing various drought affected zones of northern Karnataka was prepared.

The onset and distribution of rains during monsoon season play a very significant role in successful agricultural production. The selection of crop varieties and time for seedbed preparation are governed by onset and length of the monsoon period. The date of onset of effective monsoon (EMO) was computed based on 7 days spell, out of which, at least 4 days should be rainy days with more than 2.5 mm of rainfall (Verma and Sarma 1989). Likewise, the dry spells within the monsoon season is important especially for rainfed agriculture. The occurrence of dry spells may results in agricultural drought even if the total amount of rainfall during monsoon season is about 75% of the normal rainfall in that period. Occurrence of long dry spell during active growing season of crops, especially during fruiting and flowering stages is usually disastrous for crops. Normally, dry spell is defined as the interval of dry days (none of the day have rainfall more than 2.5 mm) between two consecutive wet spells. The criteria for the selection of dry spell is that the daily rainfall should be less than or equal to 2.5 mm (as a day is assumed as rainy day if daily rainfall exceeds 2.5 mm) occurring continuously for at least two weeks or more. For counting number of spells the start of monsoon season was assumed to be from fourth of June (beginning of 23rd standard week) every year (Verma and Sarma 1989).

RESULTS AND DISCUSSION

The percent departure of annual and seasonal (south-west monsoon) rainfall in various districts of the study area

Table 2. *Drought characteristics in the study area*

Districts/Talukas	Normal rainfall (mm)	Duration of data (years)	No. of drought years	Drought intensity	Drought frequency	Drought duration (years)
Koppal District						
Gangavati	567.00	40	8	0.37	5.00	1.90
Koppal	631.23	38	8	0.35	5.71	2.50
Kushtagi	578.59	40	7	0.39	6.67	2.10
Yelburga	565.83	40	9	0.34	4.44	2.10
Raichur District						
Deodurga	626.08	40	9	0.30	4.44	1.80
Lingsugur	572.42	40	8	0.40	5.00	1.33
Manvi	628.00	39	9	0.33	4.33	2.45
Raichur	688.54	39	7	0.33	5.57	2.50
Sindhnur	582.57	40	9	0.39	4.44	2.00
Bagalkot District						
Badami	577.87	36	7	0.34	5.14	1.75
Bagalkot	575.00	40	9	0.32	4.44	1.83
Bilgi	530.14	38	8	0.33	4.75	2.00
Hungund	555.00	36	6	0.37	6.00	1.89
Jamkhandi	526.45	38	7	0.41	5.43	1.60
Mudhol	561.08	32	9	0.40	3.56	2.13
Bijapur District						
Bagevadi	578.63	40	7	0.38	5.71	1.60
Bijapur	529.70	33	9	0.36	3.67	2.38
Indi	568.43	40	8	0.36	5.00	2.09
Muddebihal	580.51	36	7	0.39	5.14	2.50
Sindgi	616.22	39	8	0.43	4.88	1.91
Average	581.96	38	8	0.36	4.87	2.03

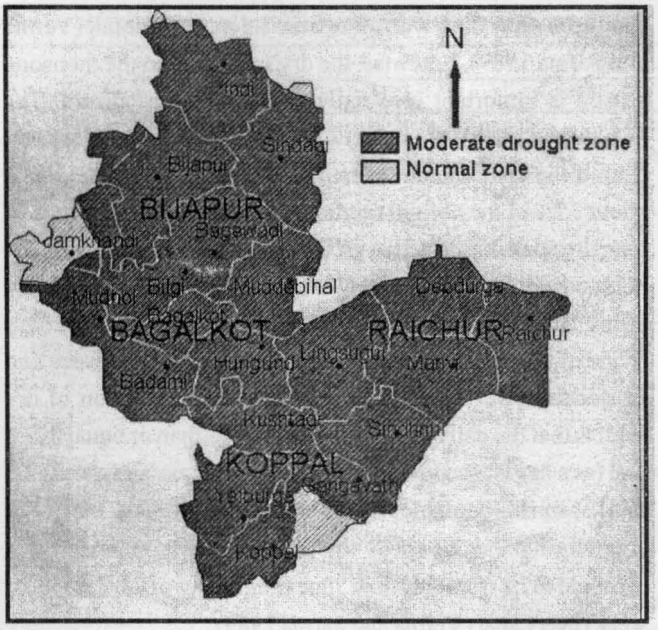

Fig. 1. *Different categories of drought affected zones in the study area*

showed a deficit of rainfall in the entire area for most of the years (Table 1). The average annual drought intensity, frequency and duration in each taluka of the study area are presented in Table 2. The computed drought intensity in the area varied from 0.30 to 0.43 with an average of 0.36. However, the average duration of drought in the study area was observed to be 2.03 years with an average return period of 5.46 years. The longest drought duration was observed at Muddebihal taluka (2.5 years) with a frequency of 6 years. The shortest average drought duration was noticed at Lingsugur taluka (1.33 years) with a recurrence interval of 5 years.

The map prepared for the region indicated that the entire study area falls under moderate drought affected zone (Fig 1). Almost 96% of the area can be categorized as moderately drought affected zone except a small part of Jamkhandi taluka in Bagalkot district and Gangavati taluka in Koppal district. The date of onset of effective monsoon (EMO) was computed based on 7 days spell. The mean date of EMO for each district was computed and is presented in Table 3. It is observed that the effective monsoon commences from the last week of June. The earliest probable date for EMO is 7th June, while 10th July is the last probable date for EMO. This information can be used for crop planning in the area. The results on average numbers of dry spells and its length in days (Table 3) reveal that the area experiences on an average two dry spells of 22 days length.

Table 3. *Computation of onset of effective monsoon and dry spell*

Districts/Talukas	Mean date of EMO	Earliest date of EMO	Latest date of EMO	Numbers of Dry Spell	Length of Dry Spell (Days)
Koppal District					
Gangavati	18th June	4th June	2nd July	2	23
Koppal	20th June	9th June	1st July	2	21
Kushtagi	19th June	8th June	30th June	3	22
Yelburga	29th June	12th June	2nd July	3	23
Raichur District					
Deodurga	30th June	13th June	17th July	2	20
Lingsugur	28th June	14th June	12th July	2	24
Manvi	24th June	5th June	13th July	3	22
Raichur	26th June	10th June	12th July	2	22
Sindhnur	26th June	10th June	12th July	2	23
Bagalkot District					
Badami	22nd June	1st June	13th July	2	20
Bagalkot	20th June	4th June	6th July	2	22
Bilgi	21st June	4th June	8th July	2	22
Hungund	21st June	2nd June	10th July	2	24
Jamkhandi	21st June	2nd June	10th July	2	21
Mudhol	20th June	6th June	1st July	2	24
Bijapur District					
Bagevadi	23rd June	6th June	10th July	2	20
Bijapur	23rd June	12th June	4th July	2	24
Indi	22nd June	1st June	14th July	2	22
Muddebihal	26th June	8th June	14th July	2	23
Sindgi	28th June	9th June	18th July	2	23
Average		23rd June	7th June	10th July	2 22

CONCLUSIONS

The study revealed a deficit of rainfall over the entire study area. The drought intensity varies from 0.30 to 0.43 with 4 to 5 years of recurrence interval. The entire area except some talukas falls under moderate drought affected zone. On an average, two dry spells with an average length of 22 days may occur. The effective monsoon season commences from the last week of June, which can be used for crop planning.

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REFERENCES

Apparao, G. and Vijayaraghavan, G. S. 1983. *Study of 1982 kharif agricultural drought over India. Vayu Mandal*, India Meteorological Department, New Delhi, India.

CWC. 1982. *Report on identification of drought prone areas for 99 districts*. Central Water Commission, Govt. of India, New Delhi.

Connie, A.W. and Jonathan, T.O. 1998. 2000 years of drought variability in the Central United States. *Bull. Ameri. Meteor. Soc*. 79(12).

Houghton, J. 1994. *Global Warming, the Complete Briefing*. Lion Publishing, pp. 192.

Palmer, W. C. 1957. Drought- a normal part of climate. *Weekly Weather and Crop Bulletin*, 44 (January), pp. 6-8.

Pandey, R. P. 1999. Drought studies for Kalahandi district in Orissa. *CS (AR)-12/98-99*, NIH, Roorkee.

Ponce, V. M., Pandey, R. P. and Ercon, S. 2000. Characterization of drought across the climatic spectrum. *Hydrolo. Engineering* ASCE, 5(2):145-158.

Rama Krishna, Y.S., Sastri, A.S.R.A.S., Rao, G.G.S.N. and Ramana Rao, B.V. 1984. On prediction of drought in Indian arid region. *Mausam* 35(3): 349-354.

Standing Committee on Agriculture 2003. *Drought Situation in the Country. Fourty fifth report of Department of Agricultural and Co-operation*, Lok Sabha Secretariat, New Delhi.

Verma, H. N. and Sarma, P. B. S. 1989. Critical dry spells and supplemental irrigation to rainfed crops. *Indian Soc. Water Resour.* 9(4): 12-16.

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